CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 02 - in effect as of: 1 July 2004)

CONTENTS

SECTION A. General description of project activity

A.1 Title of the project activity:

Bumbuna Hydroelectric Project

A.2. Description of the project activity:

This project will introduce hydropower into the electricity generation mix in Sierra Leone, displace current and future thermal generation and avoid sole reliance on imported fossil fuels. In the short-term, it will address a serious power deficit in the aftermath of civil war. In the medium to long term, the project will provide reliable, affordable electricity supply as a platform for sustainable growth based on the country's main indigenous renewable energy source. The project will complete a 50 MW dam that was 85% complete before a civil war stopped all project work in the late 1990s. The actual dam is complete, although the two 25 MW powerhouses, substations and transmission lines need to be finished. Currently, the water is running through the dam, and once the project is complete, impoundment will begin, which will create a reservoir. This project will measure greenhouse gas emission reductions using all of the components of ACM002, and will add a component to monitor the greenhouse gas emissions generated by the reservoir.

A.3. Project participants:

Ministry of Energy and Power, Government of Sierra Leone
National Power Authority
Government of Sierra Leone, as represented by the DNA-designate, Denis Lansana (letter of endorsement already provided)
The World Bank
QualityTonnes

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

Sierra Leone

A.4.1.1. Host Party(ies):

Sierra Leone

A.4.1.2. Region/State/Province etc.:

The Bumbuna site (HEP) is located in the north eastern region of Sierra Leone on the Seli River about 200 km northeast of its capital Freetown. The Bumbuna dam is located 4 km north of the village Bumbuna and 2.5 km upstream of the Bumbuna Falls

A.4.1.3. City/Town/Community etc:

Bumbuna

A.4.1.4. Detail of physical location, including information allowing the unique identification of this project activity (maximum one page):

The Bumbuna damsite is located on the upper reaches of the Seli (Rokel) river 200 km northeast of Freetown. The Seli is the third largest of nine major river systems in Sierra Leone. It rises in the mountainous in the northeast of the country and flows for about 100 km across the Interior Plateau in a south western direction. About 30 km upstream of Bumbuna near the village of Yiben the river flows out of the interior plateau through the Sula Mountains in a relatively deep, narrow valley cut into pre-Cambrian crystalline basement rock. After a fall of about 40m over Bumbuna Falls and the adjoining rapids it reaches the interior lowlands floodplains. It subsequently flows eastward to a second fall about 30km upstream of its estuary to the north of Freetown Peninsula. A regional road from Freetown provides direct access to Bumbuna Town and the dam site nearby.

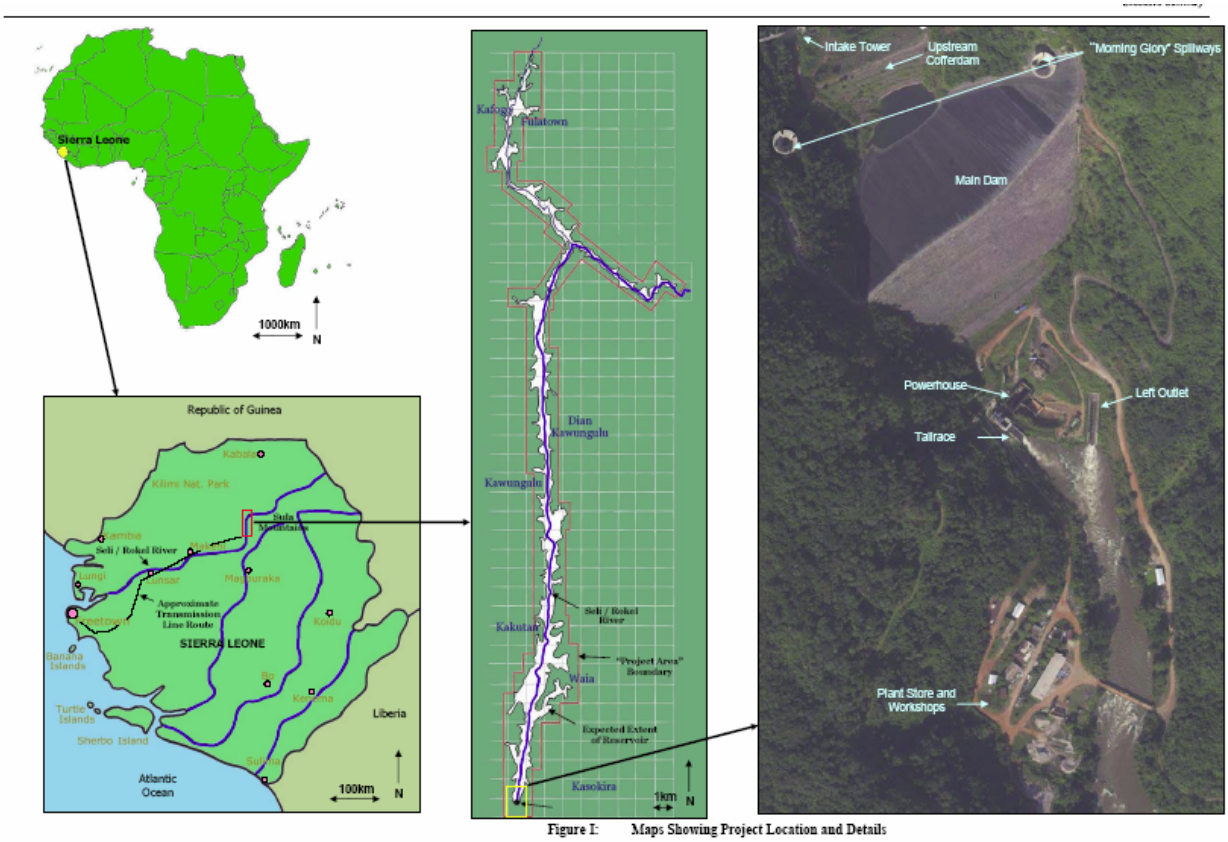


Figure 1: Maps Showing Project Location and Details

A.4.2. Category(ies) of project activity:

Catergory 1: Energy Supply (Hydropower)

A.4.3. Technology to be employed by the project activity:

The 50 MW Bumbuna Hydroelectric Power Plant consists of an 88 meter high asphalt-faced rockfilled dam with a 50 MW powerhouse (2x25 MW) at the foot of the dam. This project will complete the entire infrastructure of the dam, including the equipment in the power stations, the transmission lines and the substations.

Once completed, the dam will function at its full 50 MW capacity during the wet season and will be used for peak production (with thermal-power baseload) during the 3-4 months dry season, equivalent to 18 MW continuous capacity. The maximum seasonal drawdown of the reservoir will be about 31 meters, and the daily fluctuation of reservoir level is expected to be 0.1 meters during the dry season. The electricity generated at Bumbuna will be supplied to a substation in Freetown Peninsula via a 200 km 161 kV single-circuit transmission line.

Construction of the dam commenced in 1988 and slowed down in the early nineties due to a shortfall in financing. Construction stopped in May 1997 due to security problems at the onset of the civil war in Sierra Leone. By this time the hydroelectric plant was 85% complete. The 161 single circuit transmission line between Bumbuna and Freetown was constructed in the period 1994 - 1996. By the cessation of the construction most of the 540 towers had been built and approximately 80 km of the line had been strung. By the end of the hostilities, 29 of the towers had been destroyed or badly damaged. The whole of the line will have to be restrung with cables. Following the end of the civil war in January 2002, discussions on the completion of Bumbuna resumed. Commercial production of hydroelectric power is set to begin by 2008.

A.4.4. Brief explanation of how the anthropogenic emissions of anthropogenic greenhouse gas (GHGs) by sources are to be reduced by the proposed CDM project activity, including why the emission reductions would not occur in the absence of the proposed project activity, taking into account national and/or sectoral policies and circumstances:

This project will generate power that is currently being generated by fossil fuels. All of the electricity generated in Sierra Leone is from a thermal plant in Freetown and from off-grid generators used by industries, businesses and residents. All of this power is generated by heavy fuel oil, marine oil or diesel fuel. This project will eliminate the need for most of the off-grid generation capacity (except perhaps as backup) and may also possibly displace some of the output from the Kingtom power plant in Freetown. As a result, GHG emissions will be lowered. Without this project, GHG emissions would continue to increase as in the aftermath of civil war, more thermal units would be brought on-line. In fact, two fossil-fuel plants in the middle of the country, which were destroyed by the civil war, would be rebuilt if the Bumbuna dam is not completed. The total number of emission reductions is expected to be about 1,505,000 tonnes over the first 7 year crediting period.

A.4.4.1. Estimated amount of emission reductions over the chosen crediting period:

About 215,000 per year during the first 7-year crediting period.

A.4.5. Public funding of the project activity:

Please provide information from Parties included in Annex I on sources of public funding for the project activity which shall provide an affirmation that such funding does not result in a diversion of official development assistance and is separate from and is not counted towards the financial obligations of those Parties

This project does include some public funding, specifically from the Italian Government. The Government of Italy (GOI) has been involved in this project since the original studies The GOI indicated that the additional funding would be provided for the completion independent of any effort to gain CERs if sufficient additional funds were secured to complete the project. This funding, therefore, is not a diversion of ODA resources and is happening separately from any commitments of the Italian government to reach its Kyoto target. A brief history of Italian involvement includes the following:

- In 1972-73, the Sierra Leone Power Company engaged the Italian consulting firm Carloti, in a consortium of Canadian and Italian firms to prepare the original Bumbuna Hydropower-Development Project Study.

- In 1974 the Italian consultant firm Studio Pietrangeli from Rome was engaged by the consortium to review their work. Studio Pietrangeli was subsequently engaged by the SLEC and GoSL in 1975 to update hydrological studies and prepare power market forecasts and economic studies.

- In 1987, the Government looked to obtain partial financing for the BHP from the Government of Italy (GOI). A Financial Covenant between GoSL and GOI was agreed in 1988 for a $US 102.2 million equivalent loan for the main civil works. The main civil work at site started in 1990 when GOI loans became effective. Work stopped in 1991 due to the increasingly frequent attacks by rebels that began sporadically in the southeast had gradually spread throughout the country.

After the civil war, work has started again, with Italian contractors still involved. Thus, the Italian Government, which has already provided considerable resources into this project, has agreed to offer a grant to help finance the completion of the project. All the information necessary to demonstrate the original intentions of the Italian government in providing this grant will be given to the DOE upon project validation.

The Italian Government is not involved in the purchase of the CERs.

Finally, the World Bank involvement is funded through an IDA loan, which is concessional and can be considered ODA. However, this does not involve a diversion of ODA since IDA contributions come from countries all over the world. These contributions are not for specific projects but for IDA projects in general. Thus, IDA-contributing governments have little control over which projects receive IDA concession loans, so there can in practice be no diversion of IDA resources to projects that reduce greenhouse gas emissions.

SECTION B. Application of a baseline methodology

B.1. Title and reference of the approved baseline methodology applied to the project activity:

This methodology will build upon ACM002 "Consolidated methodology for grid-connected electricity generation from renewable sources" adding a component for calculating the GHG emissions from the creation of a reservoir, as well as a component for cases in which the grid is too small to do a proper combined-margin analysis. The title of the new methodology is Hydropower Projects that Create New Reservoirs or Expand Existing Ones.

B.1.1. Justification of the choice of the methodology and why it is applicable to the project activity:

The basic elements of ACM002 are appropriate for this project because of this project a hydropower project and meets the other applicability criteria, including: displacing power that would otherwise be provided by other generation sources through the operation and expansion of the electric sector; a persistent fuel mix not expected to change and not dominated by zero-emitting or low-cost energy resources (the dominant fuel is imported diesel and heavy fuel oil); and

This project will propose a new component, which necessitates this submission to include a new baseline and monitoring methodology. This component will measure the emissions from CO2 and CH4 from a reservoir created by a dam. These emissions will be deducted from the estimated emission reductions in order to obtain the net emission reductions from the overall project.

B.2. Description of how the methodology is applied in the context of the project activity:

The project will displace many off-grid diesel units. Sierra Leone's grid is too small for a full combined margin approach. Almost all of the electricity displaced will be from off-grid diesel units, and the project developers will use a default emissions factor to determine baseline emissions. The additional component of this project will be to measure the project emissions occurring from reservoir emissions. These emissions are expected to be low relative to other tropical reservoirs because the Seli River basin in the area of the dam site is quite steep and narrow. Normally, wide and shallow tropical reservoirs are the ones that emit the most methane and CO2.

This project will propose a method to determine what those reservoir emissions would be. The current research on reservoir emissions has determined that there is no accurate way to predict exact emissions levels. Reservoirs behave differently in different seasons, climates and topographies. Thus, the only accurate way to determine reservoir emissions will be to directly measure them using a variety of well-tested sampling methods. One of the methods this project expects to utilize requires taking air and water samples on a regular basis to devise an accurate calculation for emissions, typically measured in milligrams of gas emitted (CO2 or CH4) per square meter of reservoir surface per day. This sampling of reservoir emissions will be an integral part of the monitoring methodology. The testing and sampling techniques are described in Section D.

The reservoir emissions will be deducted from the calculations of emission reductions (from the displacement of fossil fuels for electricity generation) to obtain a figure for net emission reductions.

B.3. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity:

This project will use the Executive Board's Additionality Tool to determine that the current situation – the extensive use of solely fossil fuels to generate grid and off-grid electricity – will be the baseline scenario. The additionality test, with a description of each argument, is outlined below.

Step 0. Preliminary screening of projects started after 1 January 2000 and prior to 31 December 2005

This test is not applicable as the project will start in 2007 or 2008.

Step 1. Identification of alternatives to the project activity consistent with current laws and regulations

The only alternatives to this project are the following (each of these alternatives is in compliance with local laws):

1. Undertaking this project without the involvement of CDM or the World Bank. The reasons why this scenario is unlikely are described in Steps 2 and 3.

2. Obtaining results similar to this CDM activity through other means, such as the use of other renewable resources. Sierra Leone has few other renewable energy resources. Most energy assessments consider wind generation as having low to moderate site-specific potential. Wind velocities in Sierra Leone (as in many tropical countries) are generally low, averaging about 2-5 m/s and are largely confined to 3 months of the year. The country does have some biomass potential, mainly from agricultural waste and crop residues (the main sources being rice husk and straw, palm fruit fibres and kernel shells). Forest regeneration is another potential biomass source, though forest resources are under stress in many areas. But no studies have been done to determine how to quantify that potential accurately and develop a system for collecting and burning the biomass to generate electricity. And the resources could not reach up to the 50 MW level of Bumbuna. All of the attention to date have focused on the country's best renewable resource – hydropower. And the Bumbuna project is deemed to be one of the best locations for hydropower given its steep and narrow canyon (thus limiting land inundation).

3. Using other cleaner fossil fuels in the existing power plant, such as natural gas: No natural gas resources exist in the country, and there are no plans to build a pipeline to Sierra Leone. The West African Pipeline only goes as far as Ghana, and there is no facility to take in liquefied natural gas. Thus, there is virtually no chance any natural gas resources will be available during the crediting period.

4. Maintaining the status quo – the use of fossil fuels, specifically fuel oil, to generate both grid-connected and off-grid electricity. Based on the facts above and the barriers described below, this can be reasonably assumed to be the baseline scenario.

Step 2. Investment Analysis. Step not selected

Step 3. Barrier Analysis: The following barriers apply to this project.

- *Investment Barriers.* Sierra Leone is one of the poorest countries in the world and has suffered through a devastating civil war. Without a doubt, this project would not be completed in the absence of World Bank involvement. The country, which has no credit rating, is a purely cash economy and has virtually no private investment. The government is unable to attract anything near the level of private or foreign investment required to complete such a major project. The World Bank is financing this project through IDA credits and other soft-loan mechanisms, demonstrating the inability of the country to attract investment on commercial terms. NPA has very little cash-flow in large part because customers are unwilling to pay for the very poor level of service they receive. Many NPA employees go unpaid for months, so it is certainly not reasonable to assume a payment stream that could service private sector debt on such a significant project. The CDM component is strongly assisting in the World Bank's involvement in an otherwise high-risk environment.

- *Institutional Barriers.* The second key barrier is the lack of capacity within the country, particularly on all of the legal arrangements necessary, including the power purchase agreement, concession agreements, creation of a special purpose company to handle operation of the dam facility, etc. The lack of technical capacity to implement the project also requires international contractors and experts. None of this would be available without the World Bank's involvement due in part to CDM.

- *New Technology:* Although hydropower is a well-established technology, there are no facilities anywhere in Sierra Leone.

The project developers will provide transparent and documented evidence to the DOE, and offer conservative interpretations of this documented evidence.

Step 4. Common Practice Analysis

In spite of significant potential, there have been no major hydroelectric projects completed in Sierra Leone, thus demonstrating this type of project is certainly not common practice.

Step 5. Impact of CDM Registration:

The generation of CER revenues will have a couple of key impacts for this project:

1. Community Development: Perhaps the most important component of this project is the Community Development Benefit process. This project is designed in large part to allow local people near the Bumbuna facility to share in the benefits of the project. The government, in cooperation with the international community, established the Upper Seli Community Development Initiative (SCDI) to provide these community benefits. SCDI has allowed the project to move forward with approval from the government and from the World Bank project managers, however, the funding for the SCDI will come initially from the carbon finance revenues. Without the CER revenues, there is no on-going and

sustainable source of revenues for the SCDI, which has been a critical component in allowing the project to move through the various stages of approval.[1]

The broader proposal is the SCDI will be a forerunner of a longer-term benefit sharing mechanism, provisionally called the Bumbuna Trust. While the SCDI is focused on the Upper Seli catchment area around the dam and reservoir, the Bumbuna Trust would eventually allow all citizens in the wider basin to share the benefits of the BHP project. Essentially, the non-profit, revolving Trust will enable communities to share non-power benefits.

The Trust mechanism would allow communities in the basin ranging from small, scattered subsistence agriculture settlements to larger rural towns with formative local markets to set their own priorities for more immediate use of their monetary share of the benefits deriving from hydroelectric generation. These non-power benefits will be delivered through community-driven development mechanisms. The proponents of the SCDI – including government and local officials – listed several rationales for such a benefits-sharing program.

[1] A guiding principle of this process has been the World Commission on Dam's statements that dams are important as instruments of development, but apart from the direct provision of water and energy services, they should be conceived as part of a strategy to foster and enhance local and regional development. In addition, World Bank's Dam Planning and Management Acton Plan (DAMAP) states that "there are several ethical reasons for redistributing monetary benefits to project-affected populations and host communities"; and "dams can be conceived as part of a strategy to foster regional and local development -- "Benefit Sharing from Dam Projects Phase 1: Desk Study Draft Final Report, 2002".

Table 1.3: The value of incorporating benefit sharing arrangements in the Bumbuna HEP	
Meets immediate needs	Helps to meet the immediate needs of isolated, poor rural communities in the Upper Seli catchment, who are among the poorest in the country.
Avoids intercommunity conflict over the BHP	Ensures that indirectly affected communities see benefits at the same time as the directly affected communities nearby receive support from RAP; This reduces the risk of inter-community strife or conflict.
Avoids unfulfilled expectations in communities	Responds to widely held expectations: That inclusive approaches to local development will be pursued; That the region will not be neglected by government in the post-war era, even if rural electricity services from the Bumbuna project are deferred; That benefits they receive are directly attributed to the Bumbuna project.
Enhances development effectiveness of the BHP	Enhances the social, environment and economic development effectiveness of the project consistent with sustainable principles and the Millennium development goals.
Establishes a precedent	Establishes a timely precedent in Sierra Leone's first major hydropower project that serves as a model for future projects and builds confidence in inclusive approaches to resource development.

Initially the Bumbuna Trust would be financed through the CDM credits, as outlined in April 2005 report, "Institutional Arrangements: The Upper Seli Community Development Initiative and proposed Bumbuna Trust (p. 18). A copy of this report will be provided to the DOE. Without this financing, the Bumbuna Trust would have no source of financing, thus hindering the entire Community Benefits program, which is so central to the implementation of the Bumbuna project.

An initial menu of sub-projects has been developed during the planning process for the SCDI – through discussions with communities, wards, and districts. This menu includes access roads, water and sanitation systems, area schools and health clinics. Particular attention is also being paid to youth and training programs. Some of the more developed concepts include the following:

- A village-based marketable trade skills program for young women and men: consisting of outreach training at five or six strategic villages dispersed throughout the project area, where up to 25 youth from nearby villages will participate in a course. Additional support will provide training and sharing of experiences will be held in a village followed by practical, on-the-job experience with 'mentors' (local trades people carpenters, masons, etc.- who will take on participants as apprentices).

- A business and life skills for young men and women: an outreach training program for youth in the areas of business and life skills will also be held in the strategic villages in conjunction with the trade skills program;

- A small grant allocation scheme targeted at community-based youth organizations: where this scheme will provide a limited amount of funds to which community-based youth organizations can apply, using a simple application form.

2. Reduction of Risk to the World Bank. The Bank is already operating in a high-risk environment. Behind East Timor and Somalia, Sierra Leone is one of the poorest countries in the world. The key risk for this project is the potential for rampant non-payment of electricity bills. NPA currently offers poor to virtually no service, yet consumers receive bills with demand charges. This has created a culture where few people actually pay their electricity bills. With the introduction of more reliable electricity, this may change, but it will take time. In the likely case there is substantial non-payment, NPA will have trouble generating the cash flow needed to service the debt. Despite the fact that this is a sovereign loan, guaranteed by the Government of Sierra Leone, having CER's generated, which are paid in hard currency, will play a major role in reducing the credit risk associated with this project. It should help reduce any shortfall in revenues not coming in due to non-payment of electricity bills.

3. Payment for Monitoring of Methane Emissions: In order to get CER revenues, this project will have to calculate accurately the CH4 and CO2 emissions from the reservoir. This will require significant training and new technology never before brought into the country. A portion of the CER revenues will help pay for the infrastructure to manage that monitoring (see Section D.4), which could serve as a basis and model to determine the GHG impacts of other hydroelectric facilities. The result would be a major contribution to the debate on the role of dams in developing countries.

B.4. Description of how the definition of the project boundary related to the baseline methodology selected is applied to the project activity:

As with the other zero-emission, grid-connected electricity projects, the **spatial extent** of the project boundary includes the project site and all power plants connected physically to the electricity system that the CDM project facility is connected to. In the case of Sierra Leone, the project boundary shall also include off-grid diesel generators (all of which except for small residential units must be licensed by the National Power Authority – a project participant). Most of the power from these generators will be displaced by the availability of cheaper hydropower. Finally, the boundary will include the reservoir itself, as the emissions from this portion of the project will be considered project emissions.

B.5. Details of baseline information, including the date of completion of the baseline study and the name of person (s)/entity (ies) determining the baseline:

An initial baseline study has been undertaken in February 2005 by Seth Baruch, QualityTonnes.

SECTION C. Duration of the project activity / Crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

December, 2006

C.1.2. Expected operational lifetime of the project activity:

40 years

C.2 Choice of the crediting period and related information:

C.2.1. Renewable crediting period

C.2.1.1. Starting date of the first crediting period:

December, 2006

C.2.1.2. Length of the first crediting period:

Seven years

C.2.2. Fixed crediting period:

Option Not Selected

C.2.2.1. Starting date:

N/A

C.2.2.2. Length:

N/A

SECTION D. Application of a monitoring methodology and plan

D.1. Name and reference of approved monitoring methodology applied to the project activity:

This methodology will use elements of ACM002 – small grid-connected zero-emissions renewable electricity generation – but will add a component for monitoring the project emissions, the methane and CO2 emissions that are emitted from the creation of a reservoir. The methodology will also make an allowance for determining the carbon emissions factor in cases when the grid is too small to make a proper combined-margin analysis. The new proposed methodology is called "Hydropower Projects that Create New Reservoirs or Expand Existing Ones."

D.2. Justification of the choice of the methodology and why it is applicable to the project activity:

This methodology is justified because in the case of Bumbuna, a small reservoir will be created. The way to determine the emissions from that reservoir will be to use the sampling technique proposed in this

methodology. This reservoir is also likely to emit methane from layers of water that are stratified and where the bottom layers are anoxic (lacking oxygen), leading to degradation of biomass through anaerobic processes. Where the water is well oxygenated, degradation of biomass generates carbon dioxide, not methane.

This project will monitor emissions of methane and CO2 that are emitted from the reservoir in the way proposed by this methodology. The preferred method will be the use of air sampling at representative points in the reservoir to measure the increase in concentrations of GHGs that are emitted into chambers. Samples of the gases within the chamber will be taken over a short period of time to calculate emissions at that point, as measured in milligrams of gas (CH4 or CO2) emitted per square meter per day. These samples will be taken over different sections as the reservoir (since reservoir emissions or "flux" can vary at different points of the reservoir – often depending on depth or type of vegetation flooded). Samples will also be taken at many times during the year since flux also varies according to season and weather. All together, this testing and sampling process should obtain an accurate estimate of GHG emissions from a reservoir created by the Bumbuna dam.

D.2. 1. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario

D.2.1.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived: Studies indicate that hydroelectric power reservoirs can emit substantial amounts of methane and carbon dioxide. Methane is emitted from reservoirs that are stratified and where the bottom layers are anoxic, leading to degradation of biomass through anaerobic processes. Where the water is well oxygenated, degradation of biomass generates carbon dioxide, not methane. In either case, it will be important to monitor GHG emissions. Reservoirs that risk being potent emitters of methane are those in warm latitudes, and which are extensive and stratified with anoxic layers.[2]

The current scientific thinking around this issue is that it is impossible to tell beforehand how much reservoir emissions there will be. Emissions will vary depending on a number of factors, and thus the most practical way to determine emissions is to simply monitor them after the dam impoundment takes place. There are methods available to monitor these emissions, and two options are presented in this methodology.

ID number *(Please use numbers to ease cross-referencing to D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
2-1	Different categories to measure in flux testing	Dam operator	Number	Estimated	Once	100%	Electronic	See "Number and Frequency of Tests" section
2-2	Emissions of CH4 at each testing	Dam operator	Milligrams of gas emitted per	Measured	Every Other Month	Sampled	Electronic	

[2] To prevent stratification, water can be mixed. For example, using a free air mixing system can help reduce CH4 emissions by anchoring a horizontal perforated pipe to the bed of the reservoir, connected to a supply of air from a compressor at the surface. As the air bubbles rise they draw in water from the surrounding area, which sets up large counter-rotating cells in the adjacent water column. If the pipework was set up in the dry before impoundment begins this would provide a means of preventing stratification, which has been widely used in reservoirs elsewhere.

	site in each category to be tested		sq. meter					
2-3	Emissions of CO2 at each testing site in each category to be tested	Dam operator	Milligrams of gas emitted per sq. meter	Measured	Every Other Month	Sampled	Electronic	
2-4	Sq. meters of reservoir surf area fitting ea category	Dam operator	Square meters	Estimated	Every other month	100%	Electronic	*Surface area of reservoirs can change from season to season (eg: wet season, dry season, etc.)*
2-5	For degassing, concentratio n of CH4 in water at point of intake	Dam operator	Milligrams of gas in concentratio n per liter or cubic meter	Measured	Every Other Month	Sampled	Electronic	
2-6	For degassing, concentratio n of CH4 in water downstream of dam	Dam operator	Milligrams of gas in concentratio n per liter or cubic meter	Measured	Every Other Month	Sampled	Electronic	*Note: total degassing is determined by subtracting CH4 concentration per unit of volume downstream of dam (between .05 and 1.0 km) from CH4 concentration at point of intake. That number is multiplied by total volume of water moving through dam during the testing period (2-7)*
2-7	Total volume of water moving through dam during testing period	Dam operator	Liters or cubic meters	Measured	Daily	100%	Electronic	

D.2.1.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

This methodology proposes to be applied in cases where reservoirs are created or expanded. Studies indicate that hydroelectric power reservoirs can emit substantial amounts of methane, as well as CO2. Methane is emitted from reservoirs that are stratified and where the bottom layers are anoxic (lacking oxygen), leading to degradation of biomass through anaerobic processes. Where the water is well oxygenated, degradation of biomass generates carbon dioxide, not methane. Based on extensive research and field measurements, it is impossible to tell beforehand how much reservoir emissions there will be. Emissions will vary depending on a number of factors, and thus the most practical way to determine emissions is to simply monitor them after the dam impoundment takes place. This methodology will therefore monitor emissions of methane and CO2 that are emitted from reservoirs. The preferred method will be the use of air sampling at representative points in the reservoir to measure the increase in concentrations of GHGs that are emitted into chambers. Samples of the gases within the chamber will be taken over a short period of time to calculate emissions at that point, as measured in milligrams of gas (CH4 or CO2) emitted per square meter per day. These samples will be taken over different sections as the reservoir (since reservoir emissions or "flux" can vary at different points of the reservoir – often depending on depth or type of vegetation flooded). Samples will also be taken at many times during the year since flux also varies according to season and weather. All together, this testing and sampling process should obtain an accurate estimate of GHG emissions from a reservoir created by a dam. The exact procedures are described in the project emissions section of the monitoring methodology.

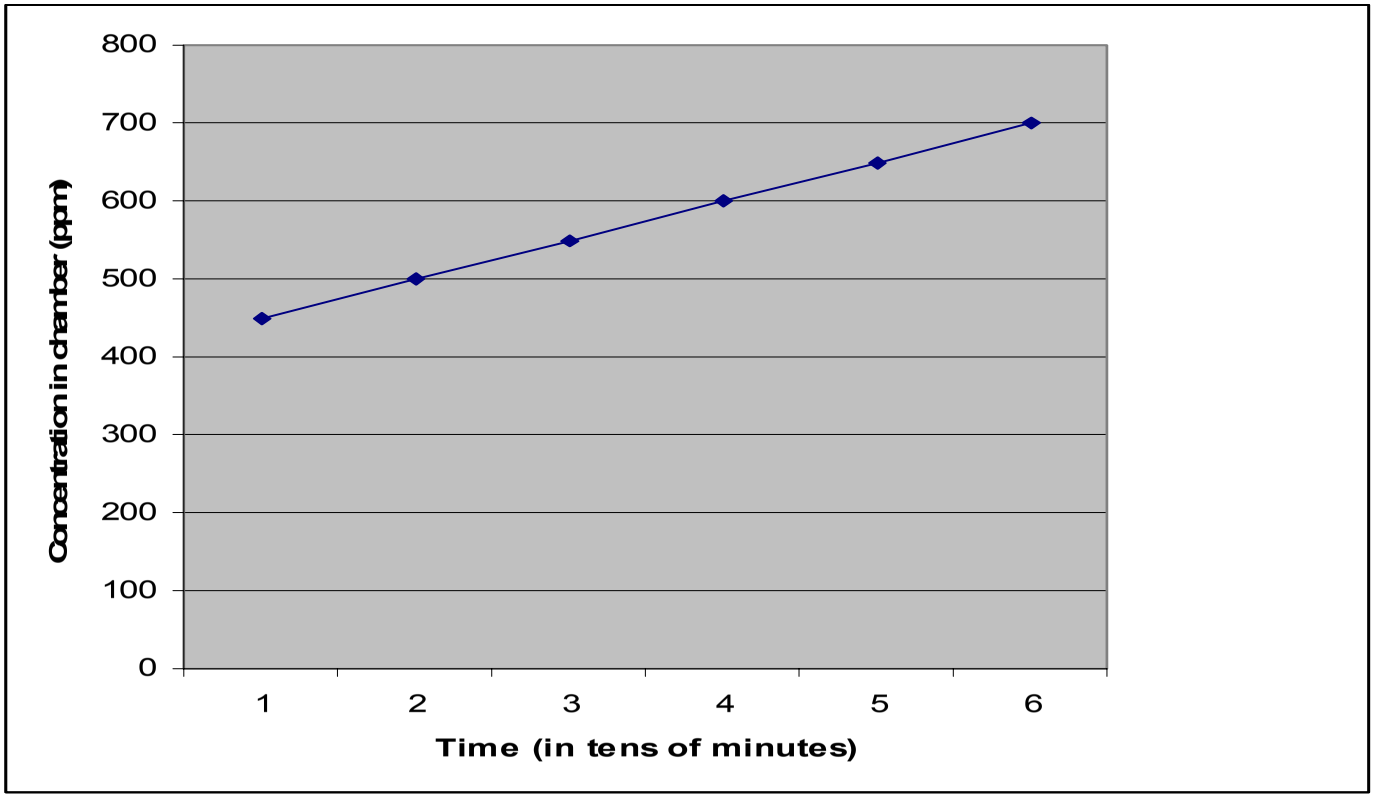
The book *Greenhouse Gas Emissions – Fluxes and Processes*, Springer Press, 2005, lists several methods by which gross GHG emissions can be measured after a reservoir is created. Because this is a relatively new area of study, this methodology will rely on one of the most-established methods, which requires sampling of air and gas concentrations at representative points across a reservoir. There are a couple of methods available, and one is described below. However, the project developers can consider using a collection device resembling a funnel that collects gas for a 24-hour period. This funnel is then sealed and sent to laboratory for analysis. If the total area of the funnel is one square meter, then the total volume of gas collected over a 24-hour period can be used to determine GHG emissions per square meter per day in that area of the reservoir.[3]

The method described below is the use of floating chambers to capture gas samples, which are then either (a) analyzed in a laboratory or (b) analyzed on site with the use of an automated instrument – either a Non-Dispersive Infrared (NDIR) or a Fourier Transform Infrared (FTIR) instrument. Tremblay, et al,

[3] In a 2000 study prepared for the World Commission on Dams, two experts, Luiz Pinguelli Rosa and Marco Aurélio dos Santos, of the Alberto Luiz Coimbra Institute (an engineering school in Brazil) conducted a number of tests of GHG emissions at Brazilian reservoirs. The general methodology was the same, however, they used a set of funnel bubble collectors (cones of synthetic fabric on an aluminum framework and coupled with gas collecting bottles). The funnels were submersed and all air removed to avoid contamination by the atmospheric air present. After this process, the collecting bottles, full of water, were coupled to the funnel. The choice of the sampling site and the arrangement of funnels were determined by parameters such as the density of the flooded vegetation, the year the reservoir was filled, depth, presence of semi submersed vegetation, and geographic region of the reservoir. The funnels were left in place for 24 hours at the site, where, during this period, the bubbles emanating from the bottom were captured. The collection bottles were then hermetically sealed while still underwater and collected for later laboratory analysis.

provide suggestions for the size and composition of the floating chamber, as well as how to prepare the chambers for testing, such as allowing time for equilibrium with local air. The proposed procedure for testing is as follows:

In the laboratory analysis or the automated instrument, the chamber is inserted into the water with the top sticking out of the water. Air is circulated through the devise, with samples being collected at specific time intervals (for the laboratory analysis, every 15 minutes for at least an hour and for the instrument analysis, every 20-30 seconds for up to 10 minutes). Each reading shows in an increase in CO2 and CH4 concentration in parts per million (ppm), as each test measures the rising concentration in the chamber. The results are plotted on a curve as demonstrated below:



The calculation of the emissions of the specific gas (flux) would use the slope of the curve (or approximate curve) and would be calculated as follows:

$$\text{Flux} = \frac{\text{slope} * F1 * F2 * \text{volume}}{\text{surface} * F3}$$

where,

slope = slope from graph of concentration versus time in ppm/minute or ppm/second
F1 = conversion factor from ppm to $\mu g \cdot m^{-3}$ (1798.45 for CO2 and 655.47 for CH4)
F2 = conversion factor to day from either minutes (for laboratory analysis, 1440) or seconds (for instrument analysis 86,400)
Volume = volume of air trapped in the chamber (m^3)
Surface = surface of the floating chamber over the water (m^2)
F3 = conversion factor from µg to mg (1000)

Flux is then measured in $mg/m^2/d$ for that location (milligrams of gas emitted per square meter of reservoir surface area per day)

Number and Frequency of Tests: In each location in the reservoir, the monitor should conduct at least three tests in order to ensure the reliability of the results. If the results are significantly different, then the monitor should conduct enough tests to obtain a certain result (at least three tests within 5% of each other). Separate tests would be done for both CH4 and for CO2.

The tests should be conducted in the same or similar points within the reservoir every other month in order to take into account seasonal differences within the reservoir. Fluxes may change from rainy to dry season, for example.

Finally, the tests should be done in different sections of the reservoir in order to get a representative sample of flux over different parts of the reservoir. The project developer should present to the DOE upon project validation what those categories of reservoir sections should be. For example, flux will vary from shallow portions of the reservoir to deeper points, as well as above different types of land that were originally flooded (forest, grassland, wetland, etc.). At project validation, the project developer should provide a map of the anticipated reservoir with all categories of sections to be tested (eg: different land areas and/or different potential depths), along with a justification of why those categories were established. At a minimum, categories of different depths of the reservoir and different types of land flooded should be provided. Each area or depth would be in one category and the project developer would have an estimate of the total number of square meters of reservoir cover that would be in each category. For example, wetlands cover will equal an estimated 2 million square meters; grassland, an estimated 3 million square meters – or 1-10 meters depth = X sq. meters, 11-20 meters depth = Y sq. meters, etc. These estimates will be provided to the DOE upon project validation.

Testing will therefore take place within each category across the reservoir, and the total flux determined by the testing will be multiplied by the total square meters within that category. For example, if the flux in the 1-10 meters depth range were 230 mg/m^2/d that would be multiplied by the area of reservoir that were 1-10 meters deep. Each flux would be multiplied by the surface area to determine total flux for the reservoir.

Total Flux Per Testing Period (6 all together in one year): Flux at each point * number of square meters in that particular category of depth or vegetation cover * number of days between that testing period and the next period (no more than 60 days).

Degassing: in many reservoirs, degassing immediately downstream of a dam can be another important source of methane emissions. This is due to the fact that the solubility of gas is greater when pressure increases, as is often the case as water moved through a dam. There is some uncertainty, however, about how quickly the methane is emitted (within seconds is possible, thus conducting the analysis described above may not be accurate). To correct for this uncertainty, the project developer should measure the concentration of methane gas dissolved in the water the level of the intake for the spillway/turbines – again, taking enough samples to get a single, reliable result. The developer can then take similar samples at a distance of about 0.5-1.0km downstream of the dam. Subtracting the two measurements will yield an estimate of the amount of methane no longer dissolved in the water downstream. That number would be multiplied by the total amount of water moving through the dam, which is then converted to a unit of mass emitted per day. This will give a good estimate of the methane lost due to degassing. For example, if samples show that at the intake, an average of 4.5 milligrams of CH4 is dissolved in a liter of water – and samples downstream show an average of 3 mg/l – then what is emitted to atmosphere is 1.5 mg/liter. That number is multiplied by the number of liters moving through the dam (which should be metered and clearly known) during the testing period (no more than 60 days). Then the test is conducted again for the next testing period.

In summary, the methodology should be as follows:

Step 1: The project developer should provide – either before the reservoir is created, or after (depending on when project validation takes place) – a complete profile of the reservoir, including the different types of vegetation and other land characteristics that were flooded, along with an estimated measure of area for each different type. The profile should also include square areas of the reservoir at different depths. This profile or map of the reservoir should be provided to the DOE. Normally, this type of information would be available in most environmental impact statements.

Step 2: The reservoir profile will be used to delineate the different zones that will require testing. The project developer will provide to the DOE a sample testing protocol (number of tests that will be done in the different zones of the reservoir) along with a schedule. Other meteorological data could also be provided to determine the rainfall patterns, seasonal variations, etc. to help the DOE evaluate – at the project validation stage – that the testing protocol provides a reasonable and statistically-accurate measurement of reservoir emissions. Finally, the testing protocol should include a description of the staffing, equipment and other needs (such as a boat) that will be required, as well as the management structure for carrying out the monitoring (who will be responsible, how data will be collected and archived, etc.).

Step 3: After project validation and after the reservoir creation begins, the sampling according to the testing protocol will begin. All data will then be provided to the verifier upon project verification.

Total project emissions (PEy) =

$$\left[\sum_{N=1}^{N_{CH4}} \left(Flux_n * m^2{}_n * days_n\right) + DG_n\right] * GWP_{CH4} + \left[\sum_{N=1}^{N_{C02}} \left(Flux_n * m^2{}_n * days_n\right)\right]$$

- N_{CH4}=Number of tests, which correspond to the number of categories to measure CH4
- N_{C02}=Number of tests, which correspond to the number of categories to measure C02
- GWP_{CH4} = Global Warming Potential of methane (21)
- Flux = flux measured at each location within that category, measured in milligrams/square meter/day
- m^2 = square meters of reservoir surface area that correspond to that category
- Days = number of days within the testing period (between the first test and the next test)
- DG=Degassing, the flux of degassing emissions on other side of the dam, measured in the same units, which is converted from the difference in concentration of methane in the water at the point of intake and 0.5-1.0 km downstream of the dam and multiplied by the total amount of water moving through the dam. DG = (Total liters of Water Through Dam) * (Concentration of CH4/Liter at Intake Point – Concentration of CH4/Liter Downstream)

This figure will give total emissions in a given year but measured in milligrams. That number would then be multiplied by a conversion factor of 10^9 to get the figure in metric tonnes (1 metric tonne = 1,000,000,000 mg).

D.2.1.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of greenhouse gases (GHG) within the project boundary and how such data will be collected and archived:

The data to determine the baseline would use the same factors as used in ACM002, including the electricity produced by the hydro facility, the emissions factor

of the entire grid, emissions factor of the build and operating margins, GHG co-efficient of fuels and total amount of fuels, etc. However, because Sierra Leone's grid is so small and in such poor condition and because consumers rely so much on off-grid diesel generators, the project developers propose using the default emissions factor of 0.8 tons of CO2/MWH. If in future years, there are enough sizable, grid-connected generating units in Sierra Leone, and if it becomes possible to determine the build and operating margins, then the data below will be collected. Thus, the data table below is included and is identical to that presented in ACM002.								
ID number *(Please use numbers to ease cross-referencing to table)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper) and for how long	Comment
3-1	*Electricity produced hydroplant* (EG_y)	*Metered at Site*	*MWH*	*M*	*Hourly measurement , monthly recording*	*100%*	*Electronic/for the duration of the crediting period*	
3-2	*Carbon Emissions Factor for the entire grid* (EF_y)	*Public Data Sources*	*tCO2eq/MWH*	*C*	*Yearly*	*100%*	*Electronic/for the duration of the crediting period*	
3-3	*Carbon Emissions from Operating Margin* (EF_OM_y)	*Public Data Sources*	*tCO2eq/MWH*	*C*	*Yearly*	*100%*	*Electronic/for the duration of the crediting period*	
3-4	*CarbonEmissions Factor from build margin* (EF_BM_y)	*Public Data Sources*	*tCO2eq/MWH*	*C*	*Yearly*	*100%*	*Electronic/for the duration of the crediting period*	
3-5	*Total GHG emissions from grid* (TEM_y)	*Public Data Sources*	*tCO2eq/year*	*C*	*Yearly*	*100%*	*Electronic/for the duration of the crediting period*	

3-6	*Total electricity to grid, excluding low-cost, zero emission sources* ($TGEN_y$)	*Public Data Sources*	*MWH/year*	*M*	*Yearly*	*100%*	*Electronic/for the duration of the crediting period*	
3-7	*Amount of fossil fuel consumed in the grid* (i. $F_{i,y}$)	*Public Data Sources*	*Physical unit*	*M*	*Yearly*	*100%*	*Electronic/for the duration of the crediting period*	
3-8	*GHG co-efficient of each fuel* ($COEF_i$)	*IPCC*	*CO2/unit of fuel*	*M*	*Yearly*	*100%*	*Electronic/for the duration of the crediting period*	
3-9	*Electricity generation of the plant* ($jGEN_{j,y}$)	*Public Data Sources*	*MWH*	*M*	*Yearly*	*100%*	*Electronic/for the duration of the crediting period*	
3-10	*Plant identification for OM*	*Public Data Sources*	*Name*	*M*	*Yearly*	*100%*	*Electronic/for the duration of the crediting period*	
3-11	*Plant identification for BM*	*Public Data Sources*	*Name*	*M*	*Yearly*	*100%*	*Electronic/for the duration of the crediting period*	
3-12	*Total electricity generation of imported power*	*Public Data Sources*	*MWH*	*M*	*Yearly*	*100%*	*Electronic/for the duration of the crediting period*	
3-13	*Carbon co-efficient of imported electricity*	*Public Data Sources*	*TCO2/MWH*	*C*	*Yearly*	*100%*	*Electronic/for the duration of the crediting period*	

3-14	*Non Dimensional number*	*Weight factor of OM (BM)*	*-*	*M*	*Yearly or fixed*	*100%*	*Electronic/for the duration of the crediting period*	*Default weight factor is 0.5 each. If the project developer wants to use another set of values, they should be monitored with reasonable reasons to be demonstrated (Wom + Wbm=1)*
3-15	*-*	*Documented evidences*		*M*	*Once at renewal time of crediting period*	*100%*	*Electronic/for the duration of the crediting period*	*Documented evidence of the prohibitive barriers of the proposed project activity*
3-16		*Documented evidences*		*M*	*Once at renewal time of crediting period*	*100%*	*Electronic/for the duration of the crediting period*	*Documented information related to the alternatives to the project*

D.2.1.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

The formulae to determine the baseline would use the same factors as used in ACM002, including calculating the build and operating margins. However, because Sierra Leone's grid is so small and in such poor condition and because consumers rely so much on off-grid diesel generators, the project developers propose using the small-scale default emissions factor of 0.8 tons of CO2/MWH. If in future years, there are enough sizable, grid-connected generating units in Sierra Leone, and if it becomes possible to determine the build and operating margins, then the data below will be collected. Thus, the formulae are identical to that presented in ACM002.

Baseline emissions (*BEy* in tCO2) are the product of the baseline emissions factor (*EFy* in tCO2/MWh) multiplied by the electricity supplied by the project activity to the grid (*EGy* in MWh), as follows:

$$BE_y = EG_y \cdot EF_y$$

Because this is a hydropower project, the baseline scenario utilizes the method as approved in the Approved Consolidated Methodology for zero-grid connected renewables. A baseline emission factor (*EFy*) is calculated as a combined margin (*CM*), consisting of the combination of operating margin (*OM*) and build margin (*BM*). The detailed approach for the combined margin is described in ACM002.

In certain cases, a hydroelectric facility may be displacing primarily off-grid generation. Particularly in rural areas, the power grid may not reach or be in such poor quality that the effect of the project is to provide off-grid areas with electrification. These off-grid areas may even be in urban settings, particularly in the least developed countries. The small-scale methodology allows for renewable energy that supplies electricity to an electricity distribution system that is or would have been supplied by at least one fossil fuel or non-renewable biomass fired generating unit. Although the limit for the small-scale default is 15 MW, in certain cases, renewable energy facilities larger than 15 MW will face the same situation. This is the case for Sierra Leone, which is a country that has a grid is such poor operating condition that even those consumers who do have wires reaching their home or business have no electricity and thus have diesel generators. It is therefore appropriate that in this case, the small-scale default of 0.8 tons of CO2/MWH be used.[4] Virtually all of the power from Bumbuna will displace these off-grid generators. Once reliable electricity is in place, people will stop using these generators and revert to relying in the grid. Using the 0.8 default is appropriate in part because it is very conservative and is an accurate reflection of what is being displaced in this case. There is a very small power plant in Freetown, the Kingtom plant which has a capacity of about 27 MW. This is the only power plant of any meaningful size in the country. It is assumed that this power plant will not be generating less because the demand for Bumbuna will be from the vast number of consumers that do not have access to this 27 MW facility (which is often not operational in any case). If during the verification of this CDM activity it is determined that power is being displaced from Kingtom (eg: if power output is reduced in response to the influx of power from the dam), then the project developers will use the MWH displaced and take the emissions factor from the power plant when considering emission reductions. If the 50 MW from Bumbuna results in Kingtom using 18 MW instead of 27 MW, the emissions factor of those displaced MWH will be calculated from Kingtom's TCO2/MWH figure, while the rest of the MWH output from Bumbuna will use the 0.8 default. It is assumed, however, for the purpose of the PDD, that the displacement of electricity will come from virtually all of the off-grid diesel generators. These figures can be adjusted upon project verification.

The output of Bumbuna is, on average, estimated to be about 290 GWH

Thus in this case BEy = 290,000 MWH * 0.8 TCO2/MWH = 232,000 TCO2

D. 2.2. Option 2: Direct monitoring of emission reductions from the project activity (values should be consistent with those in section E).

[4] According to the small scale methodology, "For a system where all generators use exclusively fuel oil and/or diesel fuel, the baseline is the annual kWh generated by the renewable unit times an emission coefficient for a modern diesel generating unit of the relevant capacity operating at optimal load…"

Option Not Selected

D.2.2.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:								
ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

Option Not Selected

D.2.2.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

Option Not Selected

D.2.3. Treatment of leakage in the monitoring plan

The main emissions potentially giving rise to leakage in the context of electric sector projects are emissions arising due to activities such as power plant construction, fuel handling (extraction, processing, and transport), and land inundation (for hydroelectric projects . see applicability conditions above). Project participants do not need to consider these emission sources as leakage in applying this methodology. Project activities using this baseline methodology shall not claim any credit for the project on account of reducing these emissions below the level of the baseline scenario.

D.2.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

NA

D.2.3.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

NA

D.2.4. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

The emission reduction *ERy* by the project activity during a given year *y* is the difference between baseline emissions (*BEy*) and project emissions (*PEy*), as follows:

$$ERy = BEy - PEy$$

(Note: BEy is determined using the default measure of 0.8 TCO2/MWH because the electricity displaced from this project will be off-grid diesel generation – see **D.2.1.4** for explanation)

D.3. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored		
Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
2-1-7	*Medium*	The reliability of testing will be ensured simply by frequent and repetitive tests. Tests must be performed until at least three results are within 5% of each other – for each point in the reservoir and for each time period within the project year. Proper training of personnel doing the testing must also be provided.
3-1-16	*NA*	See ACM002

D.4 Please describe the operational and management structure that the project operator will implement in order to monitor emission reductions and any leakage effects, generated by the project activity

The Bumbuna project will entail several agreements. The Government will issue a concession agreement to a special purpose company (SPC). That SPC will then have a power purchase agreement to the National Power Authority, who will sell the electricity to customers. The SPC will have overall responsibility of day-to-day operations of the hydroelectric facility. The SPC will have to have the staff to conduct the field testing of the reservoir emissions. This staff person will be trained by experts who have done this testing before (these experts can be brought in by the World Bank). The SPC will also be required to have the necessary equipment (a boat, testing chambers, automated instruments and/or access to a laboratory to measure the results). The SPC will have overall management responsibility in the monitoring of project emissions, but the World Bank and the Ministry of Energy and Power will continue to monitor the SPC and randomly check on the data collected, to ensure compliance with the proposed monitoring methodology.

D.5 Name of person/entity determining the monitoring methodology:

Seth Baruch, QualityTonnes

SECTION E. Estimation of GHG emissions by sources

E.1. Estimate of GHG emissions by sources:

Based on the best estimates of the project site, the project emissions from this project will likely amount to 17,000 tonnes of CO2 equivalent per year. The testing to determine levels of GHG emissions from the reservoir will be conducted after impoundment and given to the DOE upon verification. What is described below is simply an estimate for the purposes of the PDD.

Estimates of emissions of carbon dioxide and methane from lakes have been made by a number of workers over the last decade and their findings have been summarized by Rosa et al (2002) and Tremblay *et al* (2005). Data from the more recent study, which includes observations from tropical reservoirs, suggest average emission rates of around 190 mg/m2/day for CO2 and 200 mg/m2/day for CH4. Although there is debate in the scientific community regarding the degree to which HEP schemes help to reduce emissions of greenhouse gases, these figures can be used to give at least an approximation of the potential contribution of the BHP.

The operating range of the Bumbuna reservoir is between 210 and 238 m asl. At the average of these two levels the surface area is approximately 11x106 m2. Assuming average emission rates of 190 and 200 mg/m2/d for carbon dioxide and methane respectively gives daily emission rates for the whole reservoir of 2.1 and 2.2 tonnes/day. Because of the greater 'efficiency' of methane for trapping infra red radiation, the 2.2 tonnes per day is equivalent, in relation to global warming, to 46.2 tonnes of carbon dioxide. Daily carbon dioxide equivalents for the reservoir are therefore approximately 48 tonnes/day (17,000 tonnes/year). The precise amount of project emissions will be determined by the tests described in Section D.2.3.

The methodology in Section D calls for the project developer to design categories within the reservoir, different zones that might emit different amount levels of GHG emissions because different types of lands were flooded. Based on a survey (which will be updated before project validation), the following types of lands will be flooded by the anticipated reservoir; the total area is estimated at 2,100 hectares and the following land types will be flooded as a percentage of total land.

Forest regrowth: 30% of total land flooded
Cultivated land: 12%
Mixed tree savannah: 24%
Upland savanna grassland: 1%
Fringing (Riparian) forest: 21%
River: 12%

In the forest regrowth area (Category 1), the categories can further be broken down into the length of time land has been fallow.

1-2 years fallow
3-5 years fallow
6-10 years fallow

The current farming system is dominated by shifting agriculture (i.e. slash and burn) involving the clearing of vegetation to establish rain-fed or swamp-based farming for one or two years before leaving the land fallow, and moving on to clear another area of vegetation (either re-growth/fallow vegetation, mixed forest or swamp). Fallow periods range from 3 to 15 years. In addition, the remaining forest has been extensively damaged over the years by exploitation, and now exists in small patches only, adjacent to the river. Thus, a revised survey of these categories will have to be undertaken.

The precise number and categories of tests will be submitted to the DOE, as part of the testing and sampling protocol, upon project validation (see Section D.2.3). However, the testing protocol will include sampling over parts of the reservoir that include each of the categories described above, including testing over lands inundated that were fallow for different periods of time. Finally, the testing will include parts of the reservoir that is especially shallow, such as near the shoreline, since shallow areas tend to have higher GHG emission levels. With tests taking place in one depth category (1-10 meters deep in sampled locations), as well as above each type of vegetation (listed above) that is flooded, the sampling should be representative of the entire reservoir and provide a reasonable estimate of GHG emissions.

E.2. Estimated leakage:

NA

E.3. The sum of E.1 and E.2 representing the project activity emissions:

17,000 tons per year

E.4. Estimated anthropogenic emissions by sources of greenhouse gases of the baseline:

It is estimated that Bumbuna will generate on average 290,000 MWH per year.

Although this methodology utilizes the combined margin, as set out in ACM002, an allowance is made in cases where the grid is too small or underdeveloped to properly utilize the combined margin. As stated previously, this is the case for Sierra Leone. There is one small power plant – about 27 MW – in the entire country. The rest of the electricity comes from small diesel generators, used by consumers in both the urban and rural areas. Since it is impractical to measure the efficiency and emissions factor from hundreds of generators with less than 1 MW of capacity, the project developers will look the guidance provided by the small scale methodologies which identifies the off-grid diesel generation having a carbon emissions factor of 0.8 TCO2/MWH. This factor is conservative since it assumes a high efficiency diesel generator which is typically not the case in Sierra Leone. This assumption is appropriate, because the project will likely displace the marginal demand which in the case of Sierra Leone is either met with diesel generators or simply goes unmet.

*ERy = EGy * Efy; thus, ER = 290,000 * .8 TCO2/MWH =* ***232,000 tonnes of CO2 reduced***

E.5. Difference between E.4 and E.3 representing the emission reductions of the project activity:

232,000 – 17,000 = 215,000

E.6. Table providing values obtained when applying formulae above:

Year	Tonnage
1	215,000**
2	215,000
3	215,000
4	215,000
5	215,000
6	215,000
7	215,000
TOTAL For 1st Crediting Period	**1,505,000**

(Note: **This is deemed to be conservative because based on current science and experience, it is expected that reservoir emissions will decline markedly in the first few years after impoundment.)

SECTION F. Environmental impacts

F.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:

At present, the dam is in place, but the river is in free-flow through the 9 m diameter left bank spillway tunnel (and the right bank spillway tunnel during wet season flow). After impoundment, the 88-m Bumbuna dam will create a Y shaped 30-km reservoir with two upstream branches. The width in the main river with narrow, steep valleys will vary between 200m and 1.0 km. The two upstream branches that are 7 km and 11 km long will form in flatter land and rolling hills. The maximum seasonal drawdown would be 31m, and daily fluctuations would be 0.1 m in the dry season, if the plant is used for peaking.

The energy generated at Bumbuna will be supplied to a substation in Freetown through a 200-km 161 kV single-circuit transmission line. To supply provincial centres (in the short-term until conventional substations are built), a low cost solution will be employed by energizing the shield wire above the 161 kV conductors at 35.5 kV. This arrangement will supply Makeni town from the Bumbuna substation and Lunsar town from the Freetown substation with a single-phase service limited to 4 MVA.

A summary table of the environmental impacts, which discuss affects on animal species, water quality and tree vegetation – as well as the mitigation measures recommended – are attached in Appendix 5.

F.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

The original EIA report on the project was published by Electrowatt Engineering Services Ltd and Techsult Co. Ltd. in 1996, by which time the project was close to the 85% completion point at which construction was stopped due to the civil war. (The World Bank had not been involved in financing the project up to that point.) In July 2004, Nippon Koei UK Co. Ltd. (NKUK), in association with BMT-Cordah (Cordah) of the

UK and the Environmental Foundation for Africa (EFA) based in Sierra Leone, was appointed to conduct a range of additional studies to update the EIA consisting of 18 tasks, including field studies in various disciplines. This report is available both electronically and in hard copy.

Completion of the BHP is being supervised by the Bumbuna Project Implementation Unit (PIU), which has an environmental specialist. In addition, two panels of experts are providing over-sight of the project, the Environmental and Social Advisory Panel (ESAP) and the Dam Review Panel (DRP). The two panels will meet half-yearly, and at the time of writing had met once in November 2004. The ESAP has specified a minimum downstream (environmental) flow of 6 cumecs during the dry season and 100cumecs in the wet season. The DRP has specified a number of safety features that are to be included in the Emergency Preparedness Plan (EPP).

The BHP is reviewed with respect to the World Bank 'safeguard policies', in particular the following Operational Policies (OPs):

- Environmental Assessment (OP 4.01)
- Management of Cultural Property (OP Note 11.03)
- Natural Habitat (OP 4.04)
- Forests (OP 4.36)
- Dam Safety (OP 4.37)
- Involuntary Resettlement (OP 4.12)
- Projects on International Waterways (OP 7.50)
- Indigenous People (OP 4.20)

The conclusion is that the project and its recent studies (EIA update, two RAPs, etc.) are either in compliance with the safeguard policies, or, as in the case of the last two, the policies are not applicable.

In addition to the above review, the BHP is reviewed with respect to international good practice in development planning. The issues considered were as follows:
- Past / Existing Projects
- Compensation
- Public Consultation
- Benefit Sharing
- Analysis of Alternatives
- Downstream River Flows
- Contingency Planning
- Strategic Environmental Assessment
- Capacity Building.

In each case, the conclusion is that, while the project may not have adopted appropriate international best practice in the past, it is now so doing. Further details are available in the full EIA.

SECTION G. Stakeholders' comments

G.1. Brief description how comments by local stakeholders have been invited and compiled:

The World Bank safeguard policies on Environment Assessment (OP 4.01) and Involuntary Resettlement (OP4.12) are applicable. They require that the project affected villages, individual households, as well as local NGOs and concerned stakeholders are consulted in a meaningful way. Those people who are adversely affected by the project are to receive compensation to restore their standard of living and ensure that their livelihood is restored to at least pre-project standards.

To accommodate these policies a three-step approach was followed in the main safeguard studies (the EIA Update study and the two Resettlement Action Plans - RAPs) to involve and consult with stakeholders at national, district and village levels.

Three-step processes in stakeholder interactions on safeguard studies in 2004
Step 1: Introduction and eliciting concerns
▪ Initial presentations were made to stakeholder groups on the purpose and process of each study to elicit their concerns on the key issues and the proposed approach for the study. ▪ For example, in preparing the EIA Update, a scoping meeting for national stakeholders was held based on a Scoping Report and draft Public Consultation Plan. Subsequently, on-site meetings were held with communities, traditional leaders and local government authorities to discuss the same agenda. ▪ For the RAPs, a strategy for public consultation and information disclosure was prepared followed by a series of meetings with local communities at different locations, including presentation and discussion sessions with district and local government agencies, the Paramount and Village Chiefs and elders. ▪ Issues of concern such as the process steps and specific compensation policies and grievance procedures were discussed. Methods for their involvement in the process were agreed.
Step 2: Active involvement in the data collection, surveys and evaluation
▪ The field teams for each study then met individually with the affected communities and local leaders in group meetings, in focus groups, and in interviews with individual households to establish baseline data, attitudes and expectations, and areas of concern in carrying forward the analysis. ▪ In the case of the RAPs, this involved the delineation of the areas impacted by the project and the documentation of affected family's situation, livelihoods and amenities, etc. impacted by the project. The analysis was made in relation to codified and traditional rights and entitlements. ▪ For the EIA Update this involved surveys and field data collection consulting with local resources users and collecting local knowledge. National level stakeholders in the environment and resource management agencies were interviewed and consulted throughout the process.
Step 3: Presentation, Stakeholder Review and Feedback
▪ The results of the analyses and interaction with stakeholders were then presented for discussion. For this meetings were initially held with local government officials and Paramount Chiefs followed by open community meetings. ▪ Feedback on the outcome of the local meetings was provided to the inter-agency Technical Committee for the project and national stakeholders (some of these steps are still in progress and will be part of the disclosure of the safeguard report drafts). ▪ Depending on the particular study, this led to further negotiation, or steps to present the findings and recommendations to decision-makers (national-level or local decision makers depending on the issue), and to prepare for subsequent public consultations.

Communications Plan

While each safeguard study team interacted directly with target stakeholder groups, a Communications Action Plan was developed to provide an overall communications framework for the PIU. This will help the

PIU to provide consist information and messages to the different stakeholder groups during the completion phase and as the project moves into the commissioning trials and operation stages. The stated objective is to set up two-way communication mechanisms to:

- Ensure proper and timely dissemination of information on the project status and transparency in the decision process (including the implementation of agreed provisions);
- Ensure meaningful participation of all stakeholders in the completion phase decision-making processes; and
- Facilitate public acceptance and endorsement of the Project.

The Communications Action Plan outlines a series of media and outreach programmes with public dialogue forums to raise issues and debate concerns as they arise. There will be on-site information offices in the project-affected areas (e.g. both sides of the river in the reservoir area and at convenient locations along the 200 km transmission route that will be proactive in informing the affected communities with timely information and also serve as a centre where people can receive detailed information, support services and register and resolve any grievances that arise. These arrangements are set out in the Communications Action Plan and the more specific provisions and mechanisms are contained in the RAP documents.

Engagement of Local Authorities and Project Affected Communities

1. Presently the RAP and EIA Update studies are primary main platforms for interaction with affected communities. Those responsible for decision-making at this level include the local government and traditional authorities in the affected areas, e.g. Paramount Chiefs of Bumbuna, Fadugu, Kondembaia and Makeni, and the Local District Councils of Bombali in Makeni, Koinadugu in Kabala, and Tonkolili in Magburaka, as well as the Village Chiefs, community elders and other influential people in the communities such as teachers. The mechanisms for interaction have to date followed the 3-step approach indicated above. The RAPs and the EIA Update will collectively recommend mechanisms are appropriate for the completion phase and for subsequent operation phases of the project.

Engagement of national stakeholders, other audiences and interested parties

2. National Stakeholders and the public (as consumers) have a major stake in the successful completion of the project and the promised delivery of affordable power services. Print media, radio and television programs will be developed to inform the public of the project status and provide a forum for public debate (the first Radio Q&A was held on 26 Sept 2004).

3. Among the other audiences addressed by the Communication Action Plan include:

- Development Agencies and NGOs: This includes the development agencies active in Sierra Leone and particularly in the region, as well as the local and national NGOs and civil society groups to be contacted with information throughout the project implementation period and subsequently in the BHP project management and monitoring phases.
- International Stakeholders: The PIU is currently preparing material for a website that will provide international NGOs, other development agencies, civil society and professional associations with access to all safeguard studies and project implementation documents, as well as the Dam Review and Environment and Social Panel reports as they become available.

Government stakeholders

4. The primary mechanisms for government direction and cross-sector coordination are: a special Cabinet Sub-Committee; an Inter-Departmental Technical Committee; and, the Bumbuna Project Implementation Unit.

5. The Cabinet Sub-Committee established in December 2003 has a mandate to decide national energy policy with specific reference to BHP and provide oversight of a Technical Committee to help expedite decision-making. Membership consists of:

- The Vice-President of the Nation
- The Minister of Finance
- The Minster of Energy and Power
- The Minister of Works, Housing and Technical Maintenance
- The Minister of Lands, Country Planning and the Environment
- The Minister of Local Government and Community Development

6. The Technical Committee established at the same time as the Cabinet Sub-Committee has eight officials, collectively mandated to translate government approved policies into objectives and plans to be implemented by the Bumbuna PIU. It reports to the Cabinet Sub-committee on project progress including technical and financial matters and the performance of the PIU. Its mandate is to develop and promote appropriate mechanisms for all aspects of the project including those that require inter-agency coordination such as compensation issues, communications, watershed management, wildlife management and public health and safety. Membership includes:

- The Finance Secretary
- The Development Secretary
- The General Manager of NPA
- The Professional Head, The Minister of Works, Housing and Technical Maintenance
- The Chief Environment Officer, The Minister of Lands, Country Planning and the Environment
- The Bumbuna Project PIU Head
- A Representative from Professional Engineers Association and University

7. The Bumbuna PIU presently has two professional staff coordinating the safeguard and project preparation study teams. It acts as the Secretariat for the Technical Committee. The PIU will be staffing up in late 2004 with AfDB financial support. It will continue to function as the focal point for communications with national, local and international stakeholders and supervise the contracts with the project contractor and consultant.

8. It is generally recognized that how well and how effectively all the stakeholder groups are engaged in decision-making processes on completion and subsequent operation of the Bumbuna HEP will set precedents for future power projects in Sierra Leone.

G.2. Summary of the comments received:

In general, all of the people involved in the stakeholder process have been supportive of the project, both in terms of what it can provide for the country as a whole and what can be provided for the people around the community. The communities around the dam site indicated a list of potential development projects, outlined in a proposed Trust (described below).

G.3. Report on how due account was taken of any comments received:

Community Benefits Program: As part of the effort to bring societal benefits to those affected by the Bumbuna project, the World Bank will be establishing a Trust, which will be started through a $2 million

grant from the Japan Social Development Fund (JSDF). The purpose of this component is to provide communities in the Bumbuna reservoir area with projects approved by the residents themselves (through ward development committees). An initial menu of sub-projects has been developed during the planning process for the JSDF grant – through discussions with communities, wards, and districts. This menu includes access roads, water and sanitation systems, area schools and health clinics.

The report on the initial participatory work can be found in the report: *Upper Seli River Community Development Initiative for the Bumbuna Hydroelectric Project*. Eight meetings were held, bringing together representatives from stakeholder groups in the indirectly affected communities. Communities were split into various stakeholder focus groups (women, men, youth, chiefs, religious leaders, civil society, and the handicapped in order to obtain views from all segments of communities. Questionnaires were used as well as participatory techniques to arrive at a list of community priorities. This list was used to determine the two main components of the JSDF grant: community and ward sub-project and youth capacity building.[5]

Over the coming months, the Trust and several district development committees will review for proposed projects. The package of approved applications will then be sent to the district council for final approval, in coordination with the district-level staff of the relevant line ministries (for example, a proposal for a school will be checked by staff of the Education Ministry, to ensure that the Ministry can provide adequate teaching staff and equipment. A similar process will be undertaken for water projects, health projects, road projects, etc.).

[5] Training for youth was identified as a high priority in community consultations. The Social Assessment issued for Sierra Leone in April 2004 identified a focus on youth as important for post-conflict Sierra Leone. Some projects will train youth in practical skills for which there is a market demand. Priority skills mentioned in community consultations have included: roads construction, tailoring, blacksmithing, carpentry, masonry, catering, petty trade and soap making.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

Please provide information from Parties included in Annex I on sources of public funding for the project activity which shall provide an affirmation that such funding does not result in a diversion of official development assistance and is separate from and is not counted towards the financial obligations of those Parties

This project does include some public funding, specifically from the Italian Government. The Government of Italy (GOI) has been involved in this project since the original studies, indicating that the additional funding to be provided for the completion would have happened independently of any effort to gain CERs. This funding, therefore, is not a diversion of ODA resources and is happening separately from any commitments of the Italian government to reach its Kyoto target. A brief history of Italian involvement includes the following:

- In 1972-73, the Sierra Leone Power Company engaged the Italian consulting firm Carloti, in a consortium of Canadian and Italian firms to prepare the original Bumbuna Hydropower-Development Project Study.

- In 1974 the Italian consultant firm Studio Pietrangeli from Rome was engaged by the consortium to review their work. Studio Pietrangeli was subsequently engaged by the SLEC and GoSL in 1975 to update hydrological studies and prepare power market forecasts and economic studies.

- In 1987, the Government looked to obtain partial financing for the BHP from the Government of Italy (GOI). A Financial Covenant between GoSL and GOI was agreed in 1988 for a $US 102.2 million equivalent loan for the main civil works. The main civil work at site started in 1990 when GOI loans became effective. Work stopped in 1991 due to the increasingly frequent attacks by rebels that began sporadically in the southeast had gradually spread throughout the country.

After the civil war, work has started again, with Italian contractors still involved. Thus, the Italian Government, which has already poured considerable resources into this project, has agreed to provide a grant to help finance the completion of the project. All the information necessary to demonstrate the original intentions of the Italian government in providing this grant will be given to the DOE upon project validation.

Finally, the World Bank involvement is funded through an IDA loan, which is concessional and can be considered ODA. However, this does not involve a diversion of ODA since IDA contributions come from countries all over the world. These contributions are not for specific projects but for IDA projects in general. Thus, IDA-contributing governments have little control over which projects receive IDA concession loans, so there can in practice be no diversion of IDA resources to projects that reduce greenhouse gas emissions.

Annex 3

BASELINE INFORMATION

The formulae to determine the baseline would use the same factors as used in ACM002, including calculating the build and operating margins. However, because Sierra Leone's grid is so small and in such poor condition and because consumers rely so much on off-grid diesel generators, the project developers propose using the small-scale default emissions factor of 0.8 tons of CO2/MWH. If in future years, there are enough sizable, grid-connected generating units in Sierra Leone, and if it becomes possible to determine the build and operating margins, then the data below will be collected. Thus, the formulae are identical to that presented in ACM002.

Baseline emissions (*BEy* in tCO2) are the product of the baseline emissions factor (*EFy* in tCO2/MWh) multiplied by the electricity supplied by the project activity to the grid (*EGy* in MWh), as follows:

$$BE_y = EG_y \cdot EF_y$$

Because this is a hydropower project, the baseline scenario utilizes the method as approved in the Approved Consolidated Methodology for zero-grid connected renewables. A baseline emission factor (*EFy*) is calculated as a combined margin (*CM*), consisting of the combination of operating margin (*OM*) and build margin (*BM*). The detailed approach for the combined margin is described in ACM002.

However, an allowance is made in cases where the grid is too small or underdeveloped to properly utilize the combined margin. As stated previously, this is the case for Sierra Leone. There is one small power plant – about 27 MW – in the entire country. The rest of the electricity comes from small diesel generators, used by consumers in both the urban and rural areas. Since it is impractical to measure the efficiency and emissions factor from hundreds of generators with less than 1 MW of capacity, the project developers will look the guidance provided by the small scale methodologies which identifies the off-grid diesel generation having a carbon emissions factor of 0.8 TCO2/MWH. This factor is conservative since it assumes a high efficiency diesel generator which is typically not the case in Sierra Leone. This assumption is appropriate, because the project will likely displace the marginal demand which in the case of Sierra Leone is either met with diesel generators or simply goes unmet.

*ERy = EGy * Efy; thus, ER = 290,000 * .8 TCO2/MWH =* ***232,000 tonnes of CO2 reduced***

Annex 4

MONITORING PLAN

The Bumbuna project will entail several agreements, and the players involved in those agreements will be responsible for undertaking the monitoring plan. The Government will issue a concession agreement to a special purpose company (SPC). That SPC will then have a power purchase agreement to the National Power Authority, who will sell the electricity to customers. The SPC will have overall responsibility of day-to-day operations of the hydroelectric facility. The SPC will have to have the staff to conduct the field testing of the reservoir emissions. This staff person will be trained by experts who have done this testing

before (these experts can be brought in by the World Bank). The SPC will also be required to have the necessary equipment (a boat, testing chambers, automated instruments and/or access to a laboratory to measure the results). The SPC will have overall management responsibility in the monitoring of project emissions, but the World Bank and the Ministry of Energy and Power will continue to monitor the SPC and randomly check on the data collected, to ensure compliance with the proposed monitoring methodology.

The monitoring methodology for the electricity production will follow ACM002. The monitoring for the reservoir emissions will be as follows:

Step 1: The project developer will provide – either before the reservoir is created, or after (depending on when project validation takes place) – a complete profile of the reservoir, including the different types of vegetation and other land characteristics that were flooded, along with an estimated measure of area for each different type. The profile will also include square areas of the reservoir at different depths. This profile or map of the reservoir will be provided to the DOE.

Step 2: The reservoir profile will be used to delineate the different zones that will require testing. The project developer will provide to the DOE a sample testing protocol (number of tests that will be done in the different zones of the reservoir) along with a schedule. Other meteorological data will also be provided to determine the rainfall patterns, seasonal variations, etc. to help the DOE evaluate – at the project validation stage – that the testing protocol provides a reasonable and statistically-accurate measurement of reservoir emissions. Finally, the testing protocol will include a description of the staffing, equipment and other needs (such as a boat) that will be required, as well as the management structure for carrying out the monitoring (who will be responsible, how data will be collected and archived, etc.).

Step 3: After project validation and after the reservoir creation begins, the sampling according to the testing protocol will begin. All data will then be provided to the verifier upon project verification.

The Monitoring Plan will require the recording of data that will look like the following:

Year X: Sampling Results

Locations of testing	**Results of Test 1 CO2 (mg/m2/day)**	**Test 1 CH4**	**Test 2 (+ 60 days) CO2**	**Test 2 (+ 60 days) CH4**	**Test 3 (+ 120 days) CO2**	**Test 3 (+ 120 days) CH4**	**…Test 6**
1-10 meters in depth							
11-20 meters							
21-30 meters							
31-40 meters							
41-50 meters, etc.							
OR IF GEOGRAPHIC AREAS ARE USED**							

Forest regrowth (1-2 years fallow)							
Forest regrowth (3-5 years fallow)							
Forest regrowth (6-10 yrs fallow)							
Cultivated land							
Upland savanna grassland							
Fringing (Riparian) forest							
Degassing	**Test 1: CH4 sample at intake (mg/m2/day)**	**Test 1: CH4 sample downstream (mg/m2/day)**	**Test 2**	**Test 2**	**Test 3**	**Test 3**	**…Test 6**

Year X: Area of Reservoir for Each Major Category**

Category	**Sq. meters of reservoir area (Test 1)**	**Square Meters of reservoir area (Test 2)**	**Square Meters of reservoir area (Test 3)**	**…Test 6**
1-10 meters in depth				
11-20 meters				
21-30 meters				
31-40 meters				
41-50 meters, etc.				
OR IF GEOGRAPHIC AREAS ARE USED**				
Forest regrowth (1-2 years fallow)				
Forest regrowth (3-5 years fallow)				

Forest regrowth (6-10 yrs fallow)				
Cultivated land				
Upland savanna grassland				

**NOTE: A project developer may use a combination of categories in which the categories overlap. In that case, the project developer will need to subtract any double-counting. For example, if a certain percentage of "Cultivated land" is "41-50 meters" below the surface, make sure both areas are not added together, which would overstate the area of the reservoir. Subtract out the areas, and use the higher of the results for areas that overlap in more than one category. This will ensure conservative results as reservoir emissions will be estimated on the higher side – making sure that emission reduction estimates from the project are on the lower and thus more conservative side.

Annex 5: Summary of Environmental Impacts and Proposed Mitigation Measures

Executive Summary

Highly Negative | Negative | No Impacts | Positive | Highly Positive

		REMAINING CONSTRUCTION & PRE-OPERATION			OPERATION		
Issue	**Location**	**Impact**	**Significance**	**Mitigation[1]**	**Impact**	**Significance**	**Mitigation[1]**
Climate		No change in local climate. No effect globally		No mitigation necessary	Generation of electricity by hydropower instead of by thermal or diesel fuel stations will greatly reduce CO_2 emissions	Will contribute to reducing global climate change by reducing CO_2 emissions and maintaining Sierra Leone's positive carbon balance.	No mitigation necessary
Hydrology	Above dam	Impoundment is likely to begin in Jan 2006 and continue for several months. Slow flowing dry season river will gradually become a lake	Changes will only affect the reservoir area, which is relatively small. Hydrology upstream of Yiben will be unaltered	No mitigation necessary	A river with wide seasonal changes in flow will become a lake, with a surface area of 21 km^2.	Will only affect a river length of 30 km. Hydrology upstream of Yiben will be unaltered.	No mitigation necessary
	Downstream	As the reservoir is filling a minimum downstream environmental flow of 6 m^3/s will be maintained in dry season, and 100 m^3/s in Sept-Nov. Flows will vary in the final 2 months of impoundment as the scheme is tested (Commissioning).	Downstream flow will maintain natural dry season conditions and provide rainy season flow of less than the average monthly maximum flow (350 m^3/s) if the reservoir is filled in Sept-Nov. An operational rule will be introduced to prevent sudden flow changes during commissioning.	Proposed actions should avoid downstream impacts on hydrology, ecology, human users and other factors. No further mitigation is necessary.	Increased dry season flow (Jan-May) from 6-20 m^3/s to 33 m^3/s. Below normal flow in June-Aug as reservoir refills, delaying flood conditions by 5 weeks. Possible reductions in flow (evening/weekend) to retain water for times of peak demand.	Increases in dry season flow will be beneficial by avoiding severe reductions in river area that occur naturally. Rainy season impacts will not be significant as peak flood flows (Sept-Nov) and downstream inundation will not change. 5-week reduction in onset is also not of major importance with respect to hydrology. Unlikely to be any impact in estuary as changes will be masked by normal flows from the many tributaries downstream	No mitigation necessary
Sediment Load and Channel Morphology	Above dam	River sediment will be retained by dam once impoundment begins	Only small amounts will be retained during the short filling period.	No mitigation necessary	Most sediment in the river upstream will be retained by the dam	Data suggest that sediment carried by the river has increased, so sediment retention in the reservoir could be an important issue.	Will be investigated further by water quality and sedimentation studies and mitigated by improved land management in catchment.
	Downstream	Excavation of riverbed for 300 m below the dam to create the profile necessary to allow safe passage of peak flood flows. Addition of riprap and gabions to protect riverbanks.	Disturbed material could be carried downstream by river flow, but this will be a temporary impact and is thus not greatly significant.		Reduced sediment load will not cause erosion downstream because most flows will not be strong enough to mobilise mainly coarse sediments. May be some erosion in extreme floods.	Erosion and downstream deposition during extreme floods will be infrequent and will decrease with distance downstream because sediment carried by tributaries will provide the normal base load. Any changes in channel will therefore be small and not significant	No mitigation necessary
Mineral		Farmers pan for gold in	Not a major issue during the	No mitigation	Alluvial gold is found on	Some people will move up- and	Affected people will be

Nippon Koei UK, BMT Cordah and Environmental Foundation for Africa *xxiii*

		REMAINING CONSTRUCTION & PRE-OPERATION			OPERATION		
Issue	**Location**	**Impact**	**Significance**	**Mitigation[1]**	**Impact**	**Significance**	**Mitigation[1]**
Resources		the river to supplement income and will be unable to do so as reservoir fills.	relatively short period of reservoir filling.	necessary in this phase.	the river bed so panning will not be possible in the reservoir.	down-stream to continue panning. However journeys will be too far for people living near the reservoir centre so incomes will be reduced.	included in measures implemented through the RAP to stimulate small business enterprises (crafts, tourism, local services) as alternative livelihood means
Geology	Above dam	Landslips could occur during reservoir filling from soil wetting and lubrication	Landslips are unlikely as reservoir will fill gradually (in dry season) so soils will adjust to changing hydraulic conditions	Reservoir slopes will be monitored during impoundment for early detection of earth movements	Landslips could occur from wave action or by increased pore pressure in fractured rocks during the annual drawdown.	Unlikely to be a major issue as reservoir shape will reduce wave incidence, and drawdown will be gradual not sudden.	Forest will be planted in a 100 m strip along the reservoir border to retain soil.
Seismicity		Little potential for impoundment to induce seismicity because dam is in a stable area with no tectonic structures showing recent activity.	No significant impacts.	Seismograph will be installed near dam to detect any variations in background seismicity to allow remedial action.		No impact	No further mitigation necessary over the longer term.
Agriculture, Soil and Land Use	Above dam	Small-scale changes in land use as remaining buildings, access roads, etc are constructed. Gradual inundation and loss of cultivated and fallow land within reservoir area as impoundment progresses. Likely increase in clearing and agriculture on upper slopes as a result.	No significant impacts as all new structures etc will be within footprint of existing scheme See columns 6 and 7 (right) for impacts of impoundment		Loss of cultivated (250 ha) and fallow land beneath reservoir. Increased forest clearance on slopes above reservoir as farmers move uphill. Loss of soil from deforested areas and reduction in soil fertility. Improved transport of produce to market by reservoir boats.	Loss of land is not significant in terms of agriculture, as affected farmers will be provided with alternative land on which they can continue to farm. However this land is likely to be acquired from existing farmers, increasing the pressure on land by reducing fallow periods, exacerbating existing problems of poor soil fertility and erosion of soil from hillslopes.	Land management and agricultural practices in the immediate catchment will be improved by the creation of a Bumbuna Watershed Management Authority (BWMA), who will prepare and implement a Water and Land Management Strategy and Action Plan. This includes measures to reduce soil erosion and improve soil conservation, fertility and productivity.
	Downstream	No change in existing situation	No impact	No mitigation necessary	Agriculture could expand if some of the increased, reliable river flow is used for irrigation. 20,000 ha of land could be supplied (if controlled).	Potential benefit from an expanded agricultural sector, providing sufficient water remains in the river at all times to maintain a healthy ecology and fishery.	No mitigation necessary
Water Supply	Above dam	No change, as where communities use river water for domestic supply this is taken from			Reservoir will increase availability of untreated water for domestic purposes	Minor benefit	A community education campaign will be implemented to increase awareness of the risks of

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		REMAINING CONSTRUCTION & PRE-OPERATION			OPERATION		
Issue	Location	Impact	Significance	Mitigation[1]	Impact	Significance	Mitigation[1]
		streams, not the main river					drinking untreated water and the benefits of simple treatment, eg by boiling.
	Downstream	Variations in availability of river water during commissioning	Provision of a minimum environmental flow should ensure that water continues to be available for downstream users	No mitigation necessary	Increased dry season flow will increase availability of water for domestic use	Minor benefit	No mitigation necessary
Groundwater	Upstream	Water table will gradually rise in vicinity of reservoir as impoundment proceeds.	No impact on water supply or agriculture as villages will be relocated and new wells and farms will be established at the new sites.	No mitigation necessary	Water table will be higher in vicinity of reservoir	Water supply from new wells in the vicinity could reduce in the dry season as reservoir level drops.	RAP requires that resettled communities are provided with water supplies. Prior investigation will ensure that these are not affected by variations in reservoir.
	Downstream	Environmental flow should ensure that groundwater downstream is not affected	No impact	No mitigation necessary	Increased dry season flow may prevent some swamps from seasonal drying	Not significant with respect to groundwater	No mitigation necessary
Water Quality	Upstream	Poor quality (low oxygen, high BOD and nutrients) from decay of terrestrial vegetation in reservoir and organic matter in flooded soil.	Temporary impact, but could hinder development of aquatic ecology and fishery in reservoir.	Large vegetation will be removed from reservoir area before impounding. Water quality will be monitored and further action taken if necessary.	Because of its shape and lack of water movement the reservoir is likely to become stratified, with a large lower layer, devoid of oxygen because of a lack of mixing.	This could be highly negative as it will limit the development of ecology and the fishery in the reservoir and discharge poor quality water downstream, again limiting the development of ecology and fisheries.	The Dam Safety Panel do not consider that the reservoir will stratify, so a limnological study will be carried out to confirm this, and to determine the most suitable method of artificially circulating the water if necessary. This will then be installed in the reservoir.
	Downstream	Excavation of riverbed and provision of concrete & riprap bank protection downstream of dam could wash soil and other materials into river. Water released from reservoir will be poor in quality because of decaying vegetation.	Spills of fuels, cement etc could be toxic for aquatic organisms and human users. Increased sediment could affect aquatic plants and animals and make water unsuitable for human use Not of major significance as impact will be temporary and agitation of water by Bumbuna Falls will raise oxygen level in rainy season	Spills will be prevented by safe use and storage of materials on site. Excavation and construction in the river will be carried out in the dry season to reduce entry of sediment into water and transportation downstream	Improved quality river water as dam will retain suspended sediment	Benefit for aquatic ecology and human users of river water	No mitigation necessary

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		REMAINING CONSTRUCTION & PRE-OPERATION			OPERATION		
Issue	Location	Impact	Significance	Mitigation[1]	Impact	Significance	Mitigation[1]
Primates		Chimpanzees and other primates could be stranded in trees as reservoir fills.	Unlikely to be significant as impoundment is likely to occur mainly in the dry season, so water levels will rise slowly and chimpanzees will probably move gradually to higher ground in response.	Removal of trees from reservoir area to maintain water quality will avoid any possibility of chimpanzees being stranded by rising water.	Although the patchy forest mosaic in reservoir is not ideal habitat for chimps, it probably supports several communities at certain times of the year. Loss of these areas will force chimps to move elsewhere to land that will come under further pressure from farmers also displaced from reservoir.	Highly negative impact as chimps are a protected and endangered species. Habitat which several groups use will be lost, and chimps will be forced to move to other areas where they will come into conflict with humans and primates already inhabiting these areas.	Surveys will be carried out for 1 year to determine the number, size and status of all chimp communities in reservoir area. Then mitigation specific to each group will be planned and implemented. This could include: establishing forest ridge as a protected area; reforesting other areas nearby; protecting and maintaining similar habitat elsewhere in Sierra Leone.
Other Terrestrial Fauna		Some animals inhabiting the reservoir area will drown as the area is inundated and others will be exposed to increased predation (including hunting) as they move up the hillside as the impounded water rises.	This could be significant, as it may include rare and endangered primates and duikers, plus many other species.	Vegetation will be removed from the reservoir area systematically before impoundment (S to N; valley floor to upper slopes) so animals will move away in response to the disturbance. Hunting will be banned during this exercise.	Riparian forest alongside Seli River will be lost, causing habitat squeeze as primates, duikers and other animals have to move to other areas. New water body would allow populations of aquatic and semi aquatic amphibians, reptiles, mammals and birds to expand	Negative impact, but not highly significant as these habitats are small, so small numbers of animals will be affected. This can be mitigated by improved land management to increase and improve forest habitat (see below). The reservoir will increase the numbers and diversity of aquatic life, which will be of benefit to the environment and the community. Further field surveys to collect baseline data on primates, birds, butterflies, reptiles, amphibians, small mammals and bats will be conducted, as required by ESAP. Work done to date suggests that it is unlikely that riparian forest in the reservoir area supports significant endemic, endangered or otherwise special species or populations.	Conservation of these species will be improved by the BWMA implementing the Water and Land Management Strategy and Action Plan. This contains measures to: strengthen protection of all remaining forest via community education; raise awareness of effects of hunting and bushmeat consumption; establish a protected area in the immediate catchment; extend community based arms collection
Terrestrial Flora					Riparian forest in the Upper Seli catchment is probably the most northerly remaining area of Upper Guinean Rainforest. Part of this	Although riparian forest exists as a strip only 10-25 m wide along riverbanks, given its reduction over the whole of Sierra Leone and elsewhere, this loss would be highly significant.	The Water and Land Management Strategy and Action Plan includes measures to compensate for these losses. These are to: protect remaining riparian

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		REMAINING CONSTRUCTION & PRE-OPERATION			OPERATION		
Issue	Location	Impact	Significance	Mitigation[1]	Impact	Significance	Mitigation[1]
					will be lost, together with other closed moist forest and forest regrowth as resettled farmers clear new land.	Further field surveys to collect baseline data on trees and other plants will be conducted, as required by ESAP.	forest in the Upper Seli catchment by raising awareness; set up a fund and promote community forests & reforestation-afforestation programmes; allow plants to regenerate in Bumbuna quarry; establish funding to implement the National Biodiversity Strategy & Action Plan to safeguard critical habitats elsewhere in Sierra Leone
Forest		Clearing vegetation from reservoir will remove 1570 ha of forest, including 380 ha of riparian and 450 ha of mixed tree savannah, including commercially valuable trees with trunk volume of >500,000 m^3.	Loss of timber will have a negative impact on local communities who use the resource for fuel, building, manufacture, etc.	The Contractor appointed to clear vegetation from the reservoir before impoundment will be required to employ local labour and provide timber to the community free of charge.	Loss of vegetation in reservoir will increase pressure on remaining tree and forest resources in the catchment, causing further loss of soil and land degradation.	Loss of forest within and outside the reservoir would be significant in an area in which the resource is already greatly depleted. Associated soil loss and land degradation would exacerbate existing problems.	The Water and Land Management Strategy and Action Plan will compensate for losses by initiating community forestry in the immediate catchment to manage existing forest and promote reforestation and afforestation.
Catchment Management					Increased conversion of forest to cultivated land by resettled farmers, particularly on hillslopes, will increase soil erosion and further reduce soil fertility	Further soil degradation could be very significant because as well as reducing agricultural productivity, any increased sediment carried by rivers upstream will increase the sediment retained by the reservoir.	The Water and Land Management Strategy will address these and other problems caused by inappropriate land use and management practices (see above)
Aquatic Ecology	Upstream	If terrestrial vegetation is not removed, poor water quality will severely limit the ecology of the lake, as few organisms will survive in conditions of low oxygen. If vegetation is removed, lake flora and fauna will develop gradually, with initial population	If vegetation were not removed ecological impacts would be very negative as it would prevent development of a healthy ecology and fishery. Removal of vegetation will allow the development of new aquatic habitats and communities. This will be a	As much vegetation as possible will be removed from the reservoir area before impoundment.	Action will be taken to prevent stratification of the water column if necessary, and as water quality stabilises, a slightly impoverished lake community will develop (eg the periodic drying of reservoir edges will prevent significant growth of attached	Reservoir will have positive impacts by providing a lake habitat in an area where no lakes exist naturally. Benefits could increase if fish populations developed enough to support viable fisheries. The dam will not significantly affect fish migration, as Bumbuna Falls prevents migration beyond this point. Further field surveys to collect	The water column will be artificially mixed if necessary, and this will ensure positive impacts by allowing aquatic communities including fish to develop. The Water and Land Management Strategy will enhance beneficial impacts by monitoring development of aquatic

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		fluctuations, as washout of organic matter from soil will cause eutrophic conditions.	positive impact		macrophytes).	baseline data on fish and their habitats will be conducted, as required by ESAP. Work done to date suggests that no endemic, endangered or otherwise special species or populations will be found	communities and managing the reservoir to develop fisheries plus habitats and organisms (eg birds) to attract tourists. BWMA will provide equipment and training to local people for reservoir fishing.
	Downstream	Excavation of riverbed and provision of bank protection downstream of dam will remove flora and fauna. Downstream flora and fauna could also be affected by sediment and spilled materials if they enter water. Downstream aquatic ecology will not change greatly during reservoir filling as environmental flows will be the minimum natural flow in dry season (6 m^3/s), and discharges during commissioning will be similar to those that occur naturally at the same time of year (in the early rains). The flora and fauna should therefore not experience unusual harsh conditions.	Direct losses by excavation will affect a relatively small area and thus be of little significance. Depending on quantities spilled and toxicity of materials, site spillages could have more damaging impacts over a wider area No significant impacts on most aquatic flora and fauna during reservoir filling.	Spills will be prevented by safe use and storage of materials on site and work will be carried out in the dry season to reduce entry of sediment into water and transportation downstream.	Increased dry season flow should allow plants and animals to inhabit river margins permanently, so habitat and populations will increase. Fish reproduction could be disrupted by the less-than-normal flows in the early rainy season, which could disturb cues in the environment that stimulate gonad development and spawning migrations.	If plants and animals establish permanent communities at river margins this will be a significant increase in habitat and populations. This will include fish so catches and incomes could increase. This will not occur however if reservoir discharges reduce significantly at evenings or weekends to retain water. Reduced breeding success in fish could be highly negative in terms of ecology, biodiversity, the fishery and the community, if it caused populations to decline. These changes would probably not be significant in the estuary where flow from upstream of the dam is a relatively minor component of the total volume. Further field surveys to collect baseline data on fish and their habitats will be conducted, as required by ESAP. Work done to date suggests that no endemic, endangered or otherwise special species or populations will be found	Studies will be conducted to devise an operating rule that maintains a downstream flow sufficient to cover the whole riverbed at all times. Downstream fish populations and catches will be monitored during 1st year of operation, and the BHP operator will compensate fishers if breeding, catches and income are reduced. An ichthyological survey will determine whether the river supports rare or endemic species, so that conservation measures can be devised if necessary.
Socio-economics	Dam and Reservoir	Some employment opportunities for local unskilled labour during 2005 when the remaining construction is	Small scale socio-economic benefits from increases in income in the local community	See column 8	Permanent inundation and loss of 1 village housing an estimated 135 people. Loss of assets in 26 other villages	This would be a very highly negative impact if affected people were not resettled, as one village would be destroyed, 135 people would lose their homes, and 3648	A Dam and Reservoir Area Resettlement Action Plan has been prepared, which will provide new housing, farmland and other facilities

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		completed. Gradual inundation of farmland, houses and other areas and assets. Current estimates indicate that 1 village will be inundated completely and 26 others will lose land in the reservoir area, located below FSL	See column 7		(farmland, crops, timber and fruit trees, village land, footpaths, etc). An estimated 3648 people in 499 households will lose between 20 and 60% of their land. The BHP will provide electricity to several major towns and substantial parts of Freetown, inhabited by upwards of two million people.	others would lose land and assets. Living conditions will improve significantly for those people who receive and are able to afford the new supply of electricity.	(schools, markets, etc) at an alternative location (to be determined), and includes assistance with alternative livelihood strategies in agriculture, fisheries, etc. This will be agreed with the communities, who will then be resettled.
	Transmission Line Route	Displacement of people inhabiting land along the Transmission Line, to allow access for reconstruction and avoid potential health and safety impacts to people living near the transmission line. Currently 4168 persons, in 367 households are located in the 30 m wide Right of Way and 35% of these fall within the Exclusion Zone so will need to be relocated.	This would be a very highly negative impact if affected people were not resettled, as significant numbers of people would be displaced and denied acces to their homes, farms and other assets.	A Transmission Line Resettlement Action Plan has been prepared, through which PAPs will be provided with land outside the ROW and financial and technical assistance which they may use to construct improved housing. Financial compensation will also be provided for loss of assets.	The BHP will provide electricity to several major towns and substantial parts of Freetown, inhabited by upwards of two million people.	Living conditions will improve significantly for those people who receive and are able to afford the new supply of electricity.	Alternatives to relocation are also being actively considered where appropriate, including re-routing parts of the line to avoid areas of major inhabitation, and raising electricity pylons so that electromagnetic fields do not impinge upon people at ground level. If implemented this would reduce considerably the number of people to be resettled.
Culture, History, Archaeology	Dam and Reservoir	Gradual inundation of sacred shrines, other sites and artefacts, plus any archaeological material.	See column 7	See column 8	Inundation and loss of sacred shrines, other sites and artefacts, and loss of access to any as yet undiscovered archaeological sites or material.	This would be a highly negative impact if no preventative action were taken, as such sites are of considerable cultural and religious importance and their destruction could affect people psychologically and in other ways, and cause dissatisfaction and social unrest	Through the RAP, affected communities will be provided with financial compensation for loss of sacred sites, and they will be able to hold ceremonies to relocate sites and artefacts to the new village sites. Recent archaeological surveys were constrained by the density of the vegetation

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							and soil and other conditions in the rains, so additional surveys will be carried out in the dry season when the land is cleared of vegetation, to determine the area's full archaeological potential.
	Transmission Line Route	If people are resettled to sites outside the ROW they will still be able to visit sacred shrines and other sites and artefacts within the ROW. Re-stringing the towers will not involve significant ground disturbance, so there should be no damage to any undiscovered archaeological material	No impact	No mitigation necessary	In the long-term, resettled people will probably establish new sacred sites near their new houses, so visits to sites in the ROW will probably diminish.	No impact	No mitigation necessary
Tourism and Recreation	Dam and Reservoir	Bumbuna Falls would experience variable flows during Commissioning	Not a significant impact as Bumbuna Falls is not a major tourism site, and there are no other sites of tourism interest in the study area	No mitigation necessary	Bumbuna Falls will receive increased river flows in the dry season, and reduced wet season flow in July-August. BHP will create new features of potential tourism interest including the dam and reservoir and possible nature reserve to protect chimp habitat.	Increased dry season flow will extend the period in which Bumbuna Falls is an attractive waterfall. This plus the other water and landscape features (reservoir and dam) could create socio-economic benefits for the local community if action was taken to stimulate tourist interest in the area.	The BWMA will encourage and fund tourism initiatives by the local community (including provision of accommodation and infrastructure) to increase visitor numbers and provide new revenue for the community.
	Transmission Line Route	No sites with any tourism potential along ROW	No impact	No mitigation necessary		No impact	No mitigation necessary
Public Health	Dam and Reservoir	The fast flowing river will gradually change to a relatively static and expanding water body as impoundment proceeds.	30 km of fast flowing river that was suitable for egg laying by blackfly will be lost. This will be a positive impact, as it will prevent new incidents of river blindness.	See Column 8 (right) for mitigation of increased incidence of malaria.	Permanent loss of 30 km of fast flowing water suitable for egg laying by blackfly. Creation of a small area of new similar habitat at the power station outlet (through	The permanent removal of blackfly habitat will be a highly significant benefit as it will reduce the incidence of river blindness in the community. The small increase in habitat at the discharge point is not significant in comparison, but	A health protection programme will be implemented in the immediate catchment through the Upper Seli Community Development Initiative, with additional

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			However the edges of the filling reservoir may be suitable for mosquito breeding so there could be a short-term increase in the incidence of malaria during impoundment.		which water will flow rapidly). The reservoir will also provide new areas that are suitable for mosquito larvae, at the edges, and particularly in pools that will form during drawdown periods. The presence of a lake may result in more people coming into contact with slow moving water.	action should be taken to protect workers and the community from Onchocerciasis. An increase in the mosquito population will be highly negative as it will increase the incidence of malaria. Increased contact with slow moving water by swimming, bathing, washing clothes, etc, may increase both urinary and intestinal Schistosomiasis, especially the latter. This would be a significant negative impact	support from the BHP operator and BWMA. This will include: functioning and well equipped and staffed health centres providing free healthcare; identification and removal by flattening or improved drainage of all pools of standing water in the draw down area; public education on water borne diseases and prevention of infection; action to break the parasite-host cycle including removal of aquatic vectors and public health treatment (this will cover all main diseases, including Schistosomiasis, Onchocerciasis & Malaria)
	Transmission Line Route	Remaining construction and pre-operational testing will not affect river flow or drainage of swamps	No impact	No mitigation necessary	People living beneath the transmission lines may be exposed to electromagnetic radiation, about which there are human health concerns.	As yet there is no widespread agreement on whether electric and electromagnetic fields cause cancer and other health problems in humans as has been claimed. These would be highly negative impacts, if they occurred so irrespective of whether or not they are likely, mitigation should be implemented	Implementation of the RAP to resettle people from the Transmission Line will avoid potential or actual impacts on human health and reassure the public as to the safety of the BHP. Alternative action is also being considered, such as raising pylons so that electromagnetic radiation is not significant at ground level.